

require a high temperature curing or sintering step, sometimes referred to as firing, that can exceed 500° C. In contrast, according to one aspect of the present invention, the optional bonding layer **150** can be used to bond the thin glass layer **160** to the conductive film **120** at low temperatures, for example, at approximately room temperature. Low temperature processing is particularly advantageous where the conductive film **120** cannot withstand high temperature processing. For example, conductive organic layers, such as an intrinsically conductive polymer, typically cannot withstand high temperature processing. According to one aspect of the present invention, the optional bonding layer **150** can be dried and/or cured at low temperatures. For example, the bonding layer can be cured by exposure to radiation, such as Ultra Violet (UV) radiation. In the case of exposure to UV radiation, it may be advantageous for the bonding layer to include UV absorbers to protect the conductive film **120** from UV radiation. The bonding layer can also be cured at other wavelengths or wavelength ranges, such as blue or green. In one aspect of the invention, the bonding layer can be cured by exposure to gamma radiation. In another aspect of the present invention, the bonding layer can be thermally cured. The curing temperatures can be well below temperatures that could adversely affect other layers in the touch sensor **100**. In general, the bonding layer may be solidified and/or cured using any drying and/or curing technique. It will be appreciated that although it may be advantageous for the bonding layer to be solidified and/or cured at low temperatures, the bonding layer can be processed at high temperatures. For example, the bonding layer **150** can include a sol-gel and may be cured by a firing step.

[0038] An advantage of using the optional bonding layer **150** can be improved touch sensor impact and shatter resistance. Bonding layer **150** can provide adhesive support for glass layer **160** across the touch sensor area, for example, across the touch sensitive area **195**. In the event glass layer **160** breaks, the broken fragments can remain adhered to other components in touch sensor **100**, such as substrate **110**. Increased shatter resistance can permit use of a thinner glass layer **160**.

[0039] The present invention is particularly advantageous in a capacitive touch sensor or a capacitive touch display system that includes one or more layers that are sensitive to environmental factors such as oxygen and moisture, especially at elevated temperatures. Generally, permeability coefficient of organic layers can be quite high. For example, permeability coefficient of poly-methyl-methacrylate is $0.116 \times 10^{-13} \text{ (cm}^3 \times \text{cm) / (cm}^2 \times \text{s} \times \text{Pa)}$ for oxygen at 34° C. and $480 \times 10^{-13} \text{ (cm}^3 \times \text{cm) / (cm}^2 \times \text{s} \times \text{Pa)}$ for water at 23° C. (see, for example, Polymer Handbook, 4th Edition, J. Brandrup, E. I. Immergut, and E. A. Grulke, Publisher: John Wiley, & Sons, Inc., page VI/548). In sharp contrast, the permeability coefficient of a glass layer **160** is effectively zero for any permeant such as oxygen and water. As such, layer **160** can be utilized to effectively protect environmentally sensitive layers from environmental factors such as oxygen and moisture. One such environmentally sensitive layer is a conductive polymer film. Other environmentally sensitive layers include, for example, active layers used in an OLED device.

[0040] Substrate **110** can be electrically insulating. Substrate **110** may be rigid or flexible. Substrate **110** may be optically opaque or transmissive. The substrate may be

polymeric or any type of glass. For example, the substrate may be float glass, or it may be made of organic materials such as polycarbonate, acrylic, polyethylene terephthalate (PET), polyvinyl chloride (PVC), polysulfone, and the like. Substrate **110** may include a metal, in which case, the substrate can also be used as conductive film **120**.

[0041] Touch sensor **100** further includes an optional bonding layer **150** which may be optically transmissive or opaque. Bonding layer **150** is disposed between and is preferably optically coupled to the conductive film **120** and glass layer **160**. Optionally, bonding layer **150** may be in contact with either or both layers **120** and **160**. Bonding layer **150** can be optically diffusive by, for example, dispersing particles in a host material where the indices of refraction of the particles and the host material are different. Bonding layer **150** can be an adhesive. Exemplary materials incorporated in bonding layer **150** include UV curable adhesives, pressure sensitive adhesives, epoxies, urethanes, thiolenes, cyano acrylates, heat activated adhesives and thermoset adhesives.

[0042] Touch sensor **100** can be flexible or rigid. A flexible touch sensor **100** can, for example, be used to conform to a curved display, such as a curved cathode ray tube (CRT) display. In one embodiment of the invention, flexible components are used to make a rigid touch sensor **100**.

[0043] Touch sensor **100** further includes electrical circuitry **165** configured to detect a signal induced by capacitive coupling between the conductive film **120** and a touch input applied to the glass layer **160**. The detected signal can be used to determine the touch location. According to one aspect of the invention, electrical circuitry **165** includes electrodes **130** disposed on conductive layer **120** and electrically conductive leads **131** that electrically connect conductive layer **120** and electrodes **130** to electronics and controller **155**. Electrical circuitry **165** can electrically transmit the detected signal to electronics and controller **155**. Electronics and controller **155** can receive and process the detected signal to determine the touch location.

[0044] Electrodes **130** can be optically transmissive or opaque. Electrodes **130** can be formed using a conductive ink such as, for example, a thermally cured silver epoxy, or an electrically conducting composition containing an electrical conductor and glass frit where the conductor can be, for example, silver, gold, palladium, carbon or an alloy composition. Electrodes **130** can be deposited onto film **120** by, for example, screen-printing, ink-jet printing, pad-printing, direct write or decal transfer.

[0045] Touch sensor **100** can further include optional linearization pattern **140** to linearize the electric field. Typically, the linearizing electrode pattern **140** can include several rows of discrete conductive segments positioned along the perimeter of the touch sensitive area, such as disclosed in U.S. Pat. Nos. 4,198,539; 4,293,734; and 4,371,746. The conductive segments can typically be electrically connected to each other via the conductive film **120**. U.S. Pat. No. 4,822,957 discloses rows of discrete electrodes having varying lengths and spacings to linearize the electric field in a touch sensitive area.

[0046] In the exemplary embodiment shown in FIG. 1, the glass layer **160** and the optional bonding layer **150** cover a portion of the electrical circuitry **165**. In particular, they